URBDP 498/598 ENVIRONMENTAL PLANNING

Lecture 7: Indicators of Resilience

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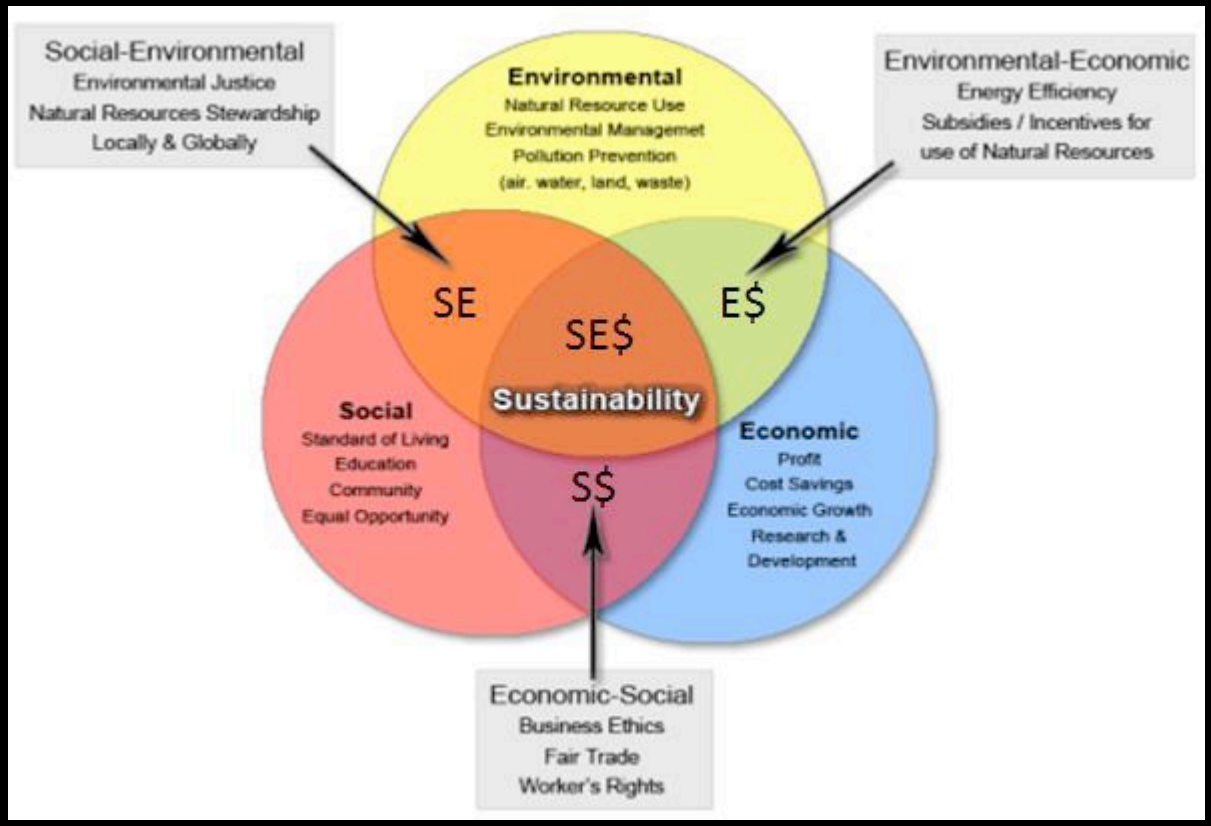
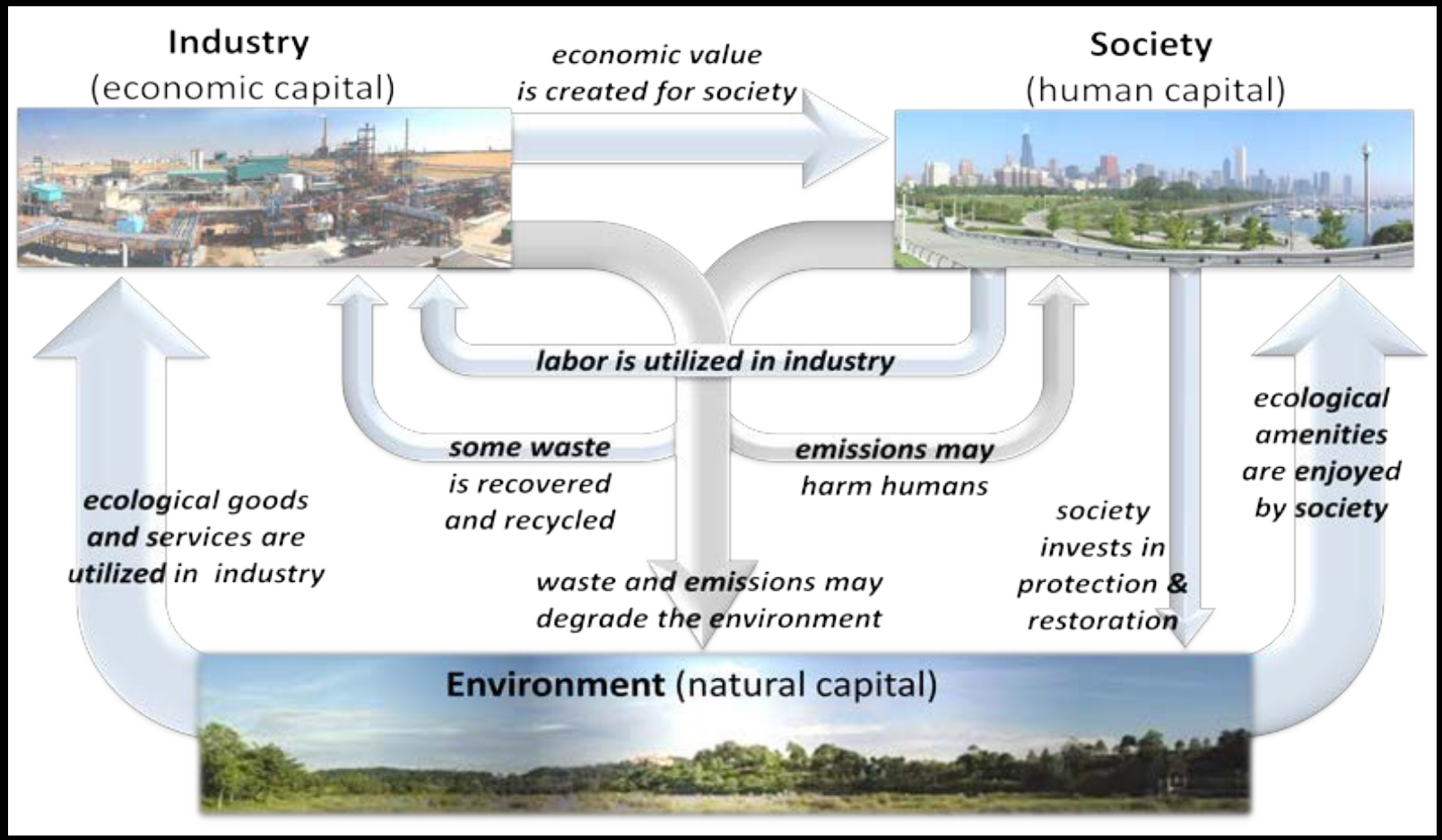
Principles of resilience, equity, and sustainability

Berbés-Blázquez et al 2021

EPA Indicators Framework



EPA Indicators Framework

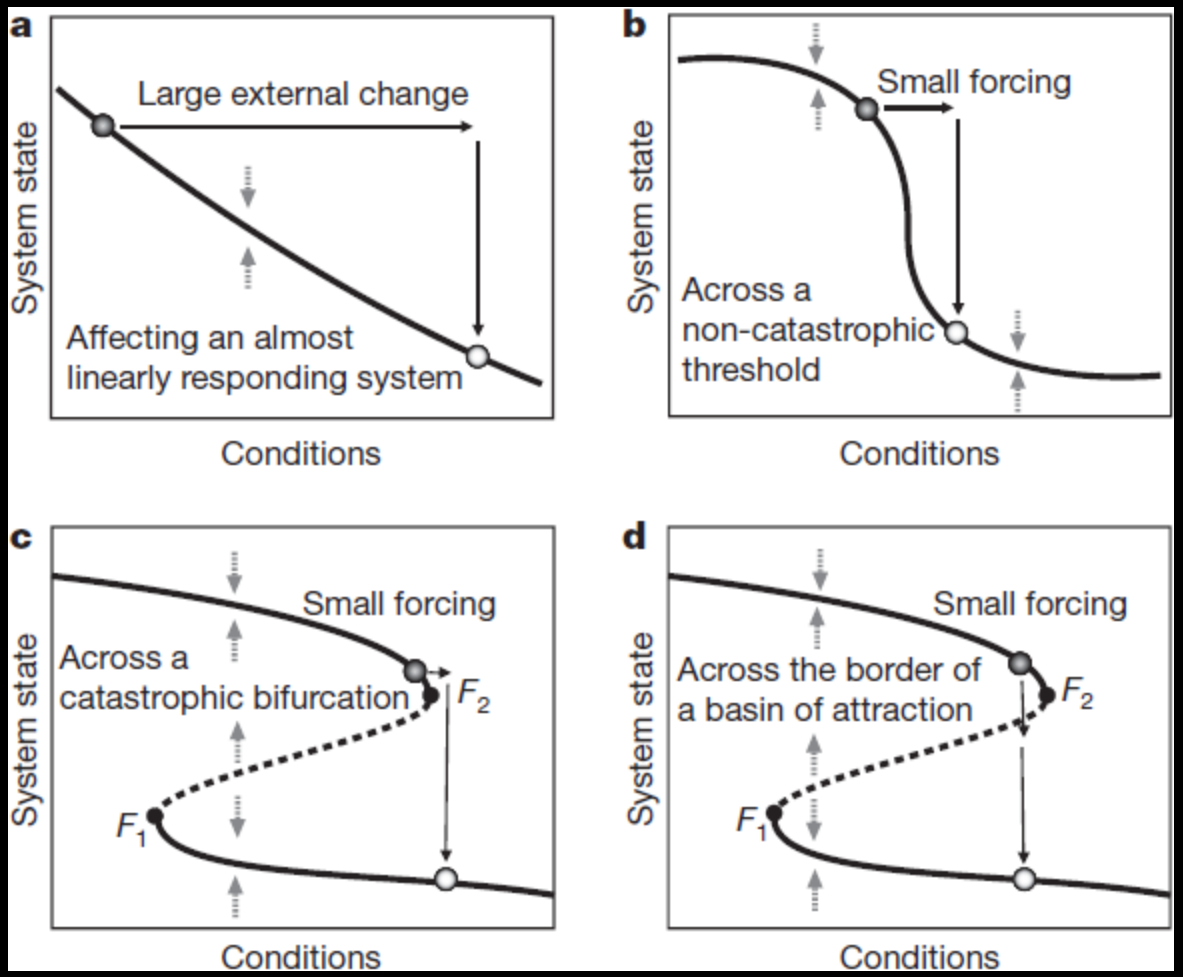


EPA Indicators Framework

Indicator Category	Indicator Types	National Scale Examples	Community Scale Examples
Resource Flow Indicators	• Volume • Intensity • Recovery • Impact • Quality	• Greenhouse gas emissions • Material flow volume • Resource depletion rate	• Greenhouse gas emissions • Material flow volume • Water treatment efficacy • Recycling rate • Land use
Value Creation Indicators	• Profitability • Economic Output • Income • Capital Investment • Human Development	• Cost (reduction) • Fuel efficiency (gain) • Energy efficiency (gain)	• Cost (reduction) • Fuel efficiency (gain) • Energy efficiency (gain) • Vehicle use (miles per capita)
Adverse Outcome Indicators	• Exposure • Risk • Incidence • Impact • Loss • Impairment	• Health impacts of air pollution • Public safety • Life cycle footprint of energy use	• Health impacts of air pollution • Public safety • Sewer overflow frequency
System Condition Indicators	• Health • Wealth • Satisfaction • Growth • Dignity • Capacity • Quality of Life	• Air quality • Water quality • Employment • Household income	• Air & water quality • Local employment • Local household income • Housing Density • Infrastructure durability • Community educational equity

Tipping Point:

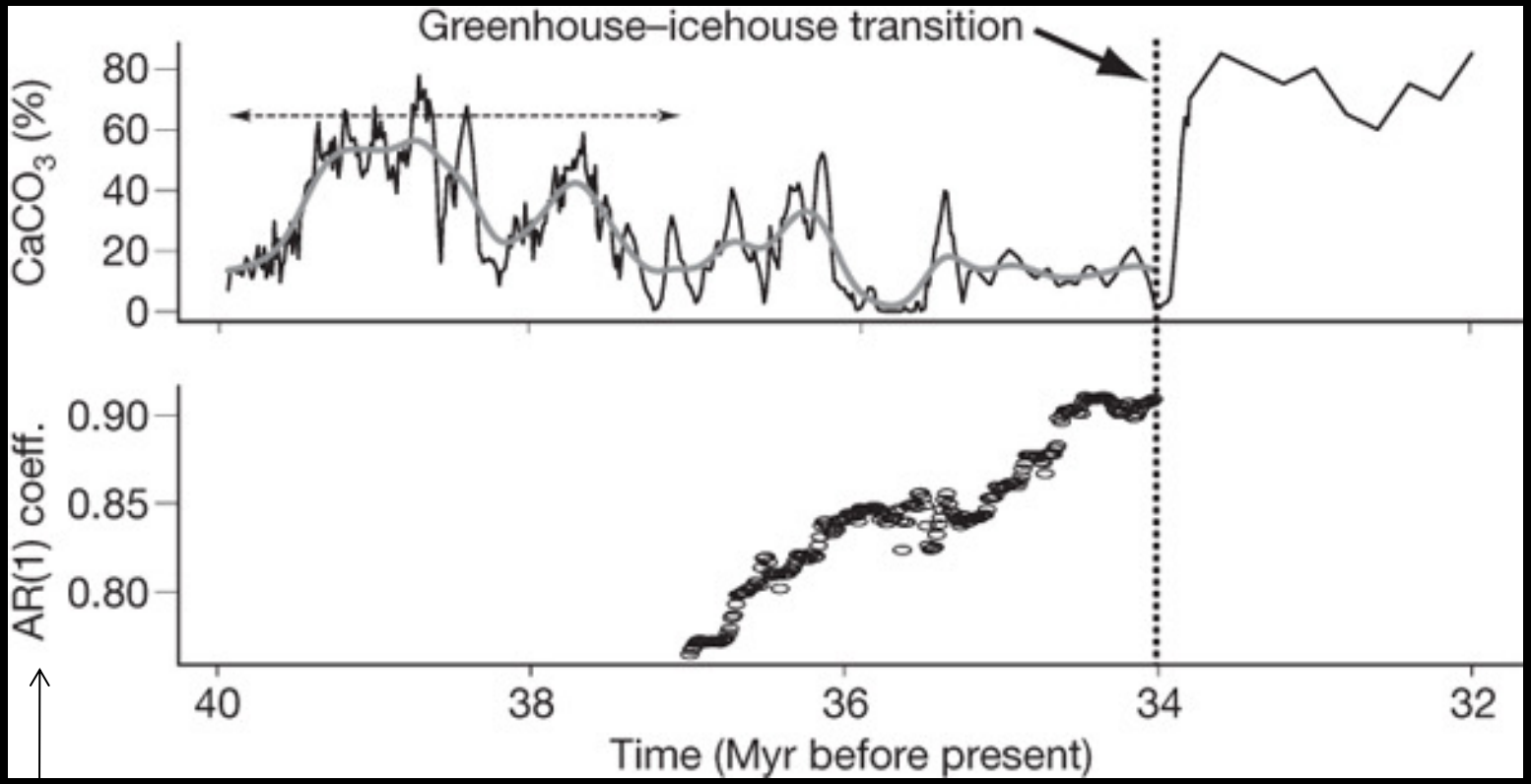
A "critical threshold at which a tiny perturbation can qualitatively alter the state or development of a system" (Lenton et al.,



Early-warning signals for critical transitions" (Scheffer et al., 2009)

Before a Critical Transition

Critical Slowing Down (Autocorrelation/Variance)
Skewness and Flickering Before Transitions



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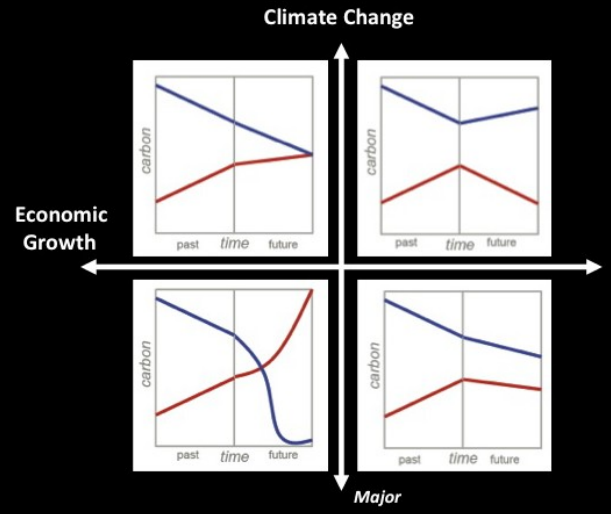
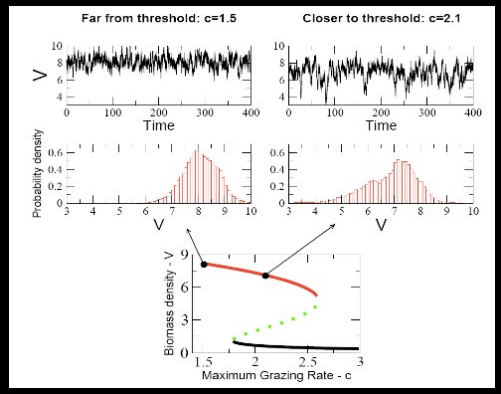
Practicum 5: Indicators of Resilience

Indicators



Indicator trajectories



Early warning

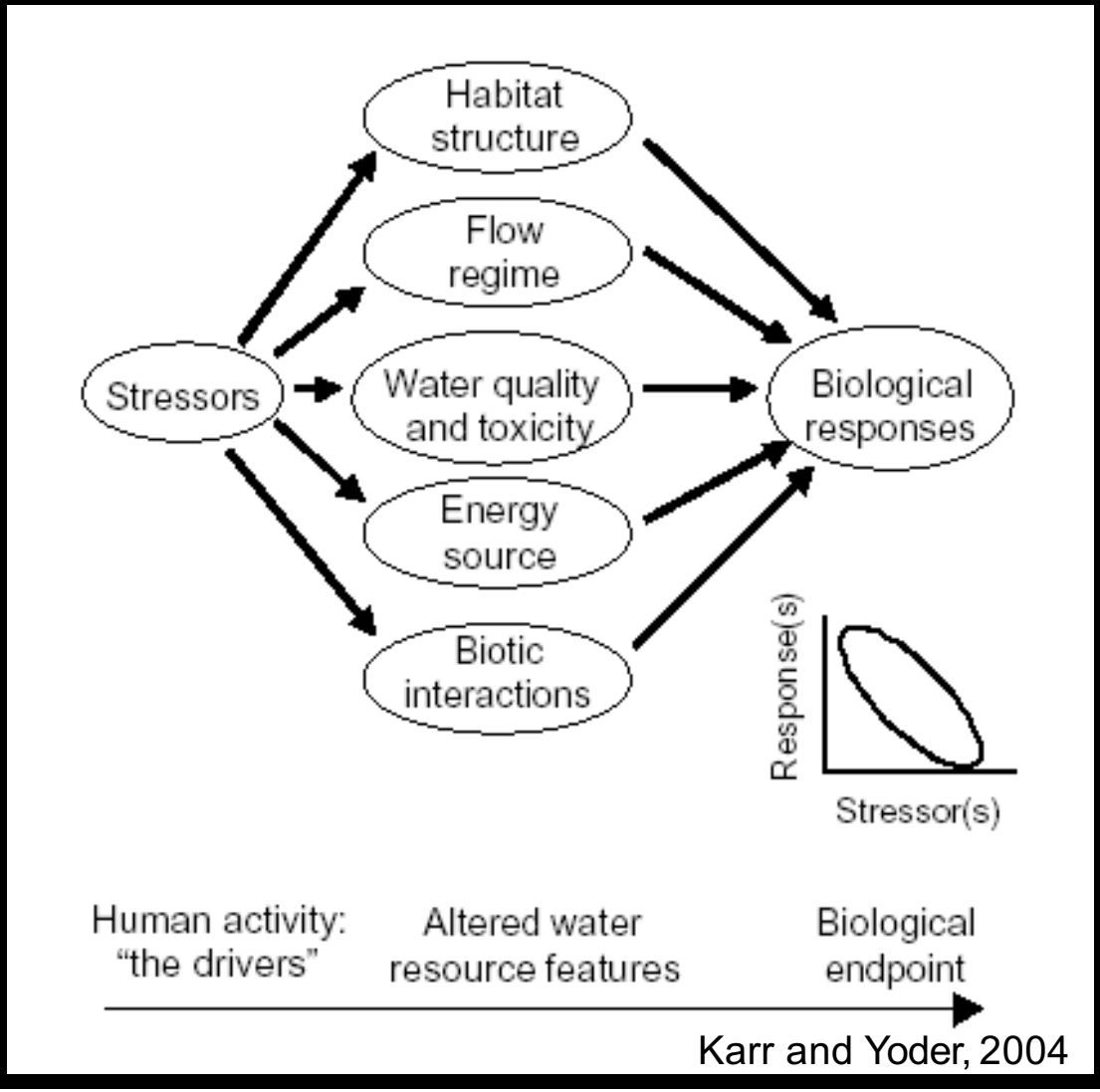
What is an Indicator

- An indicator is a parameter or a value that describes the state of a phenomenon.
  - An indicator should have significance beyond the direct parameter value.
  - An indicator should guide our understanding and action.
  - An indicator should warn us ahead of time.
  - No single indicator can fully represent a complex dynamic system

Criteria for indicator selection

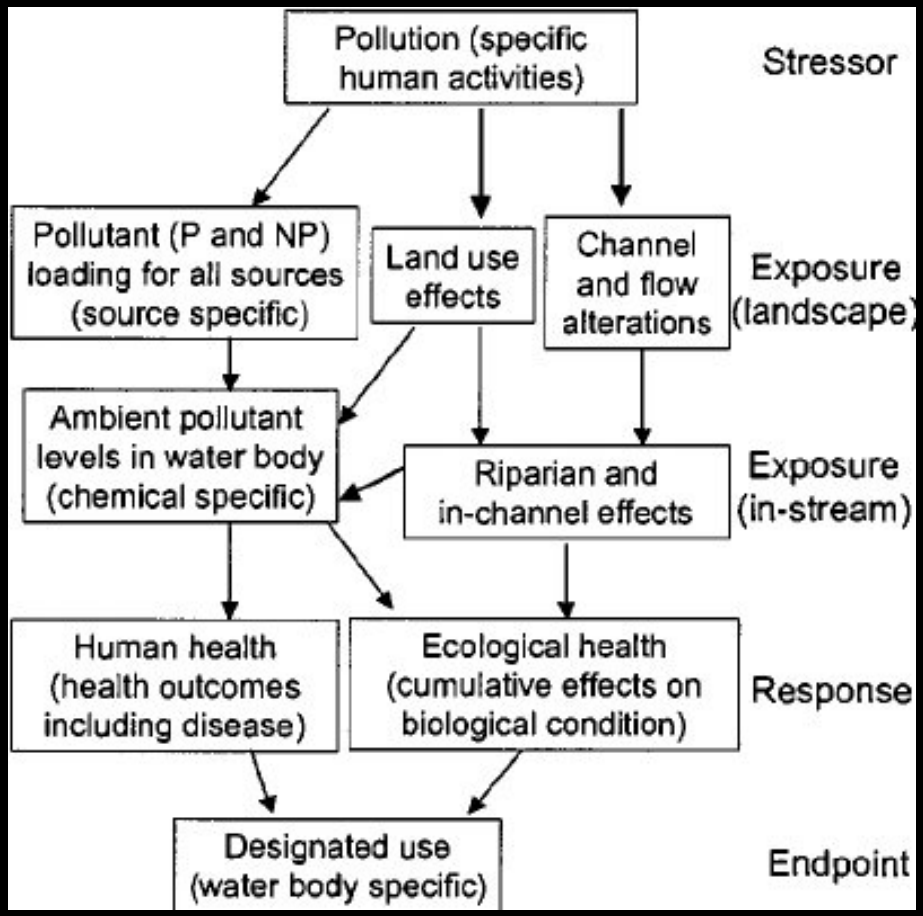
- Conceptually linked.
- Relevant to focal issue.
- Sensitive to changes in the system.
- Meaningful to decision making. Informs the assessment of problem and what we decide to do about it.
- Available and Understood at the scale, extent and variable needed.

Conceptual Model of Stream Health Indicators



Karr and Yoder, 2004

Conceptual Model of Stream Health Indicators



Conceptual Model of Stream Health Indicators

Karr and Yoder, 2004

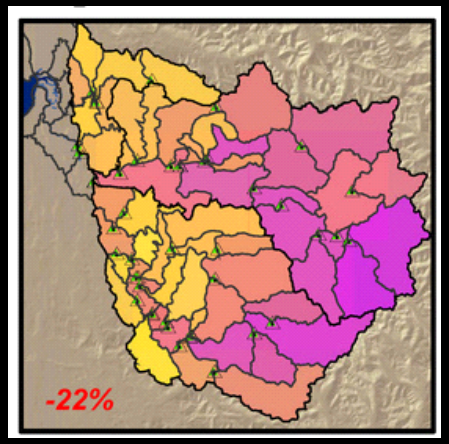
Ecosystem Services

- For the Snohomish Basin Project, the focal issue was maintaining ecosystem services over the next 50 years.
- We were specifically focusing on **water** (quality and quantity), **carbon** (storage and fluxes) and **biodiversity**.
- Ecosystem Services are the benefits or functions people obtain from ecosystems including supporting, provisioning, regulating and cultural services.

Water

- Quantity:
  - Streamflow variability due to impervious surfaces and climate change (e.g. snow melt)
  - Demand, supply: sectors + growth, conservation
  - Infiltration, including groundwater
  - Challenge for salmon, flooding, drinking water, treatment
- Quality:
  - Related to quantity
  - Pollution (runoff, emissions and discharge)
  - Temperature (relates to dO, pH)
  - Sediments

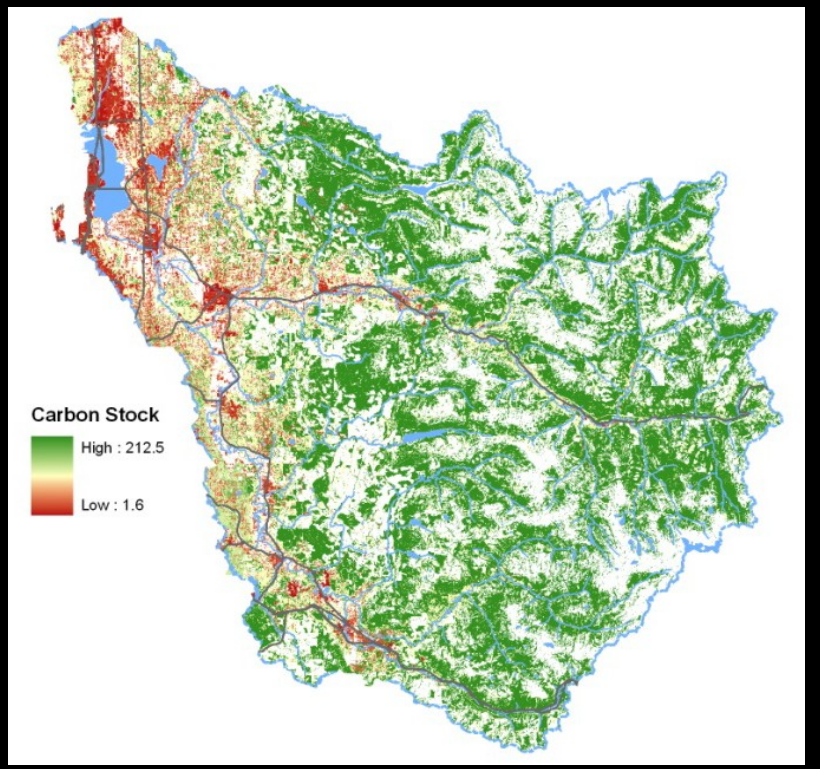
Low stream-flow 2050 projections



303d listed

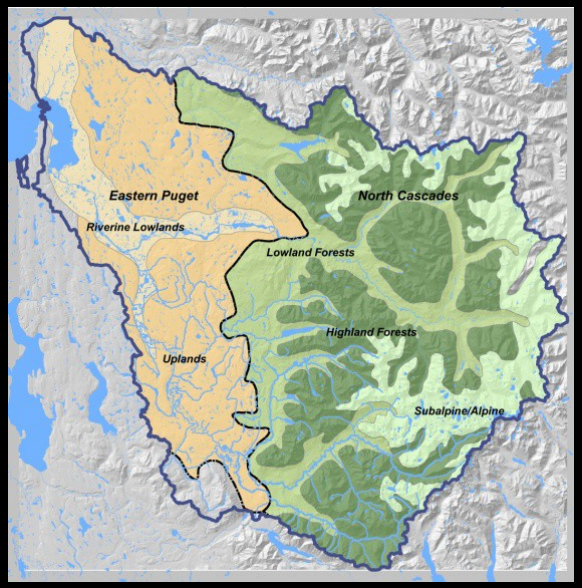
Carbon

- Stocks and flows of carbon relate to several ecosystem services including climate regulation, wood and fuel provision, cultural values, and primary production.
- Stocks
  - Urbanization: forest loss and landscape management
  - Timber
- Emissions
  - Land use / transportation
  - Behavior + technology

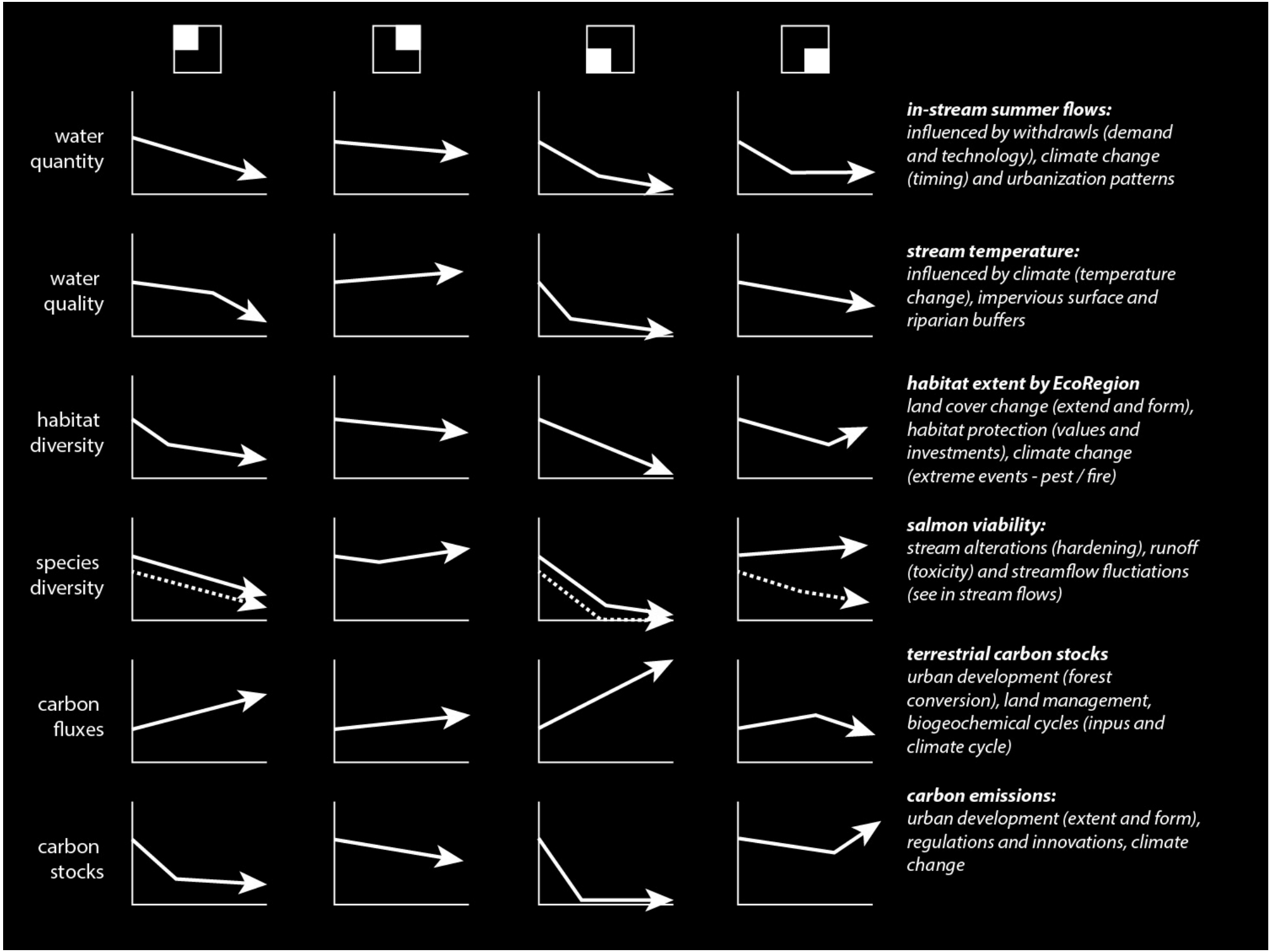


Biodiversity

- Landscapes / Habitat
  - Unique habitat
  - Wilderness protection
  - Outside / uncertain drivers (cc, critical connections)
- Species
  - Salmon, escapement
  - Invasives
  - food webs / systems

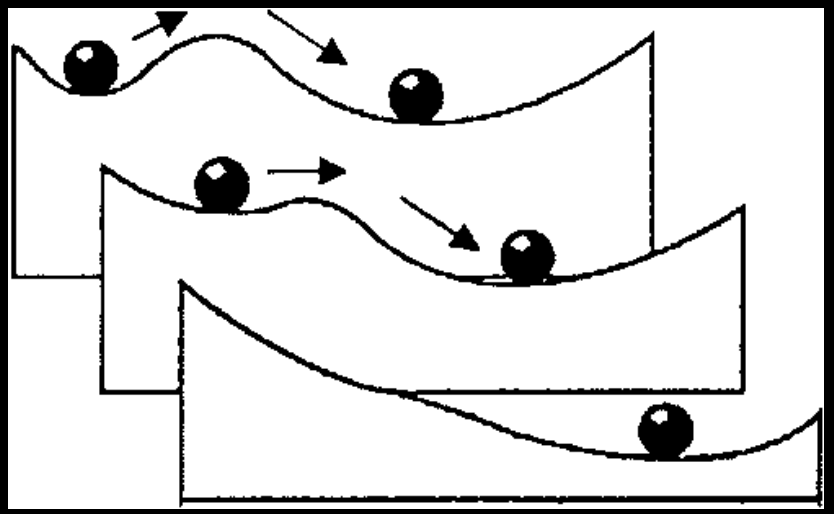


WRIA 7 EcoRegions

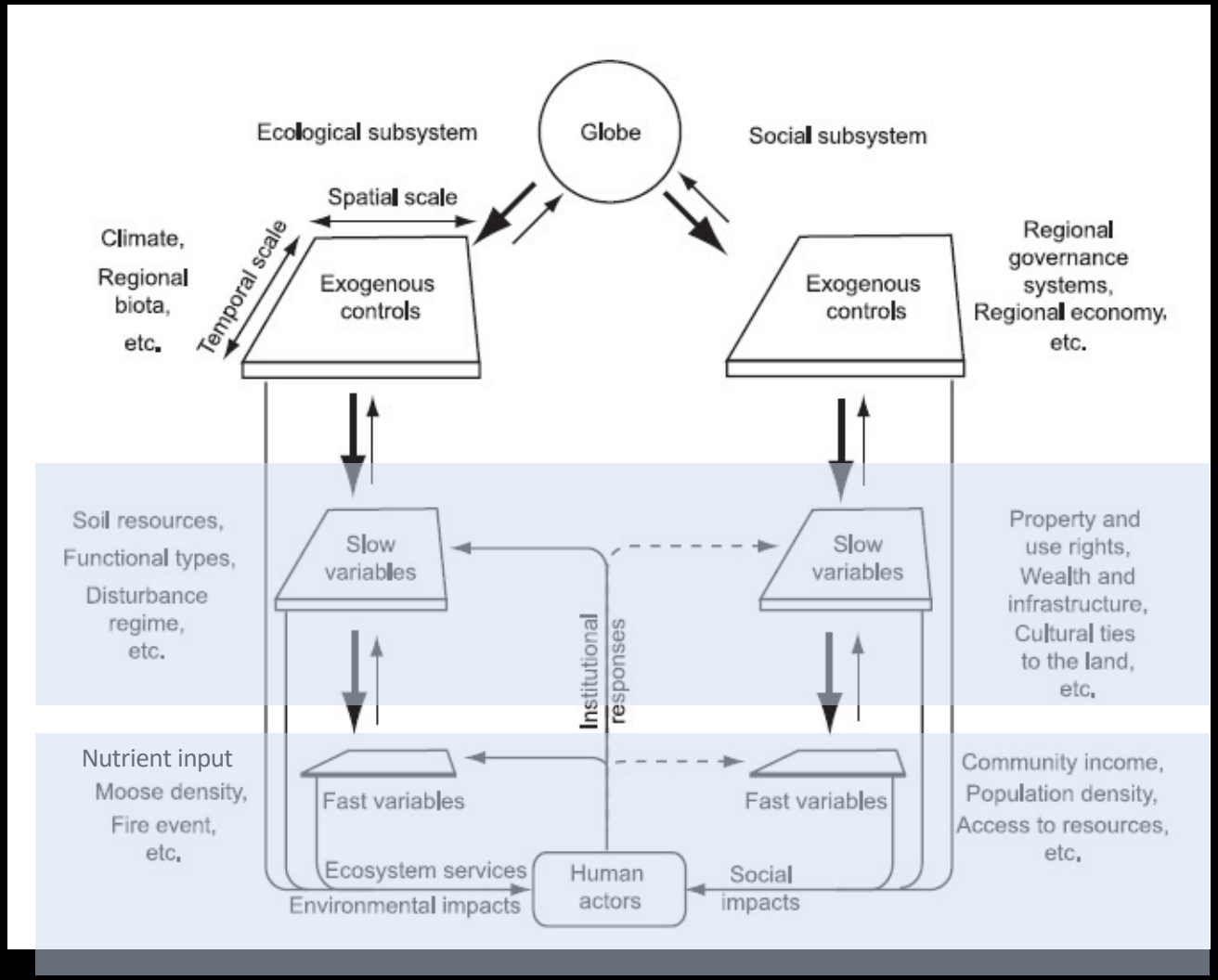

water quantity
water quality
habitat diversity
species diversity
carbon fluxes
carbon stocks
in-stream summer flows:
influenced by withdrawls (demand and technology), climate change (timing) and urbanization patterns
stream temperature:
influenced by climate (temperature change), impervious surface and riparian buffers
habitat extent by EcoRegion
land cover change (extend and form), habitat protection (values and investments), climate change (extreme events - pest / fire)
salmon viability:
stream alterations (hardening), runoff (toxicity) and streamflow fluctiations (see in stream flows)
terrestrial carbon stocks
urban development (forest conversion), land management, biogeochemical cycles (inpus and climate cycle)
carbon emissions:
urban development (extent and form), regulations and innovations, climate change

Indicators of Resilience

- How much perturbation can the system absorb?
  - What are the thresholds?
  - Where are we today?
  - How fast are we moving?



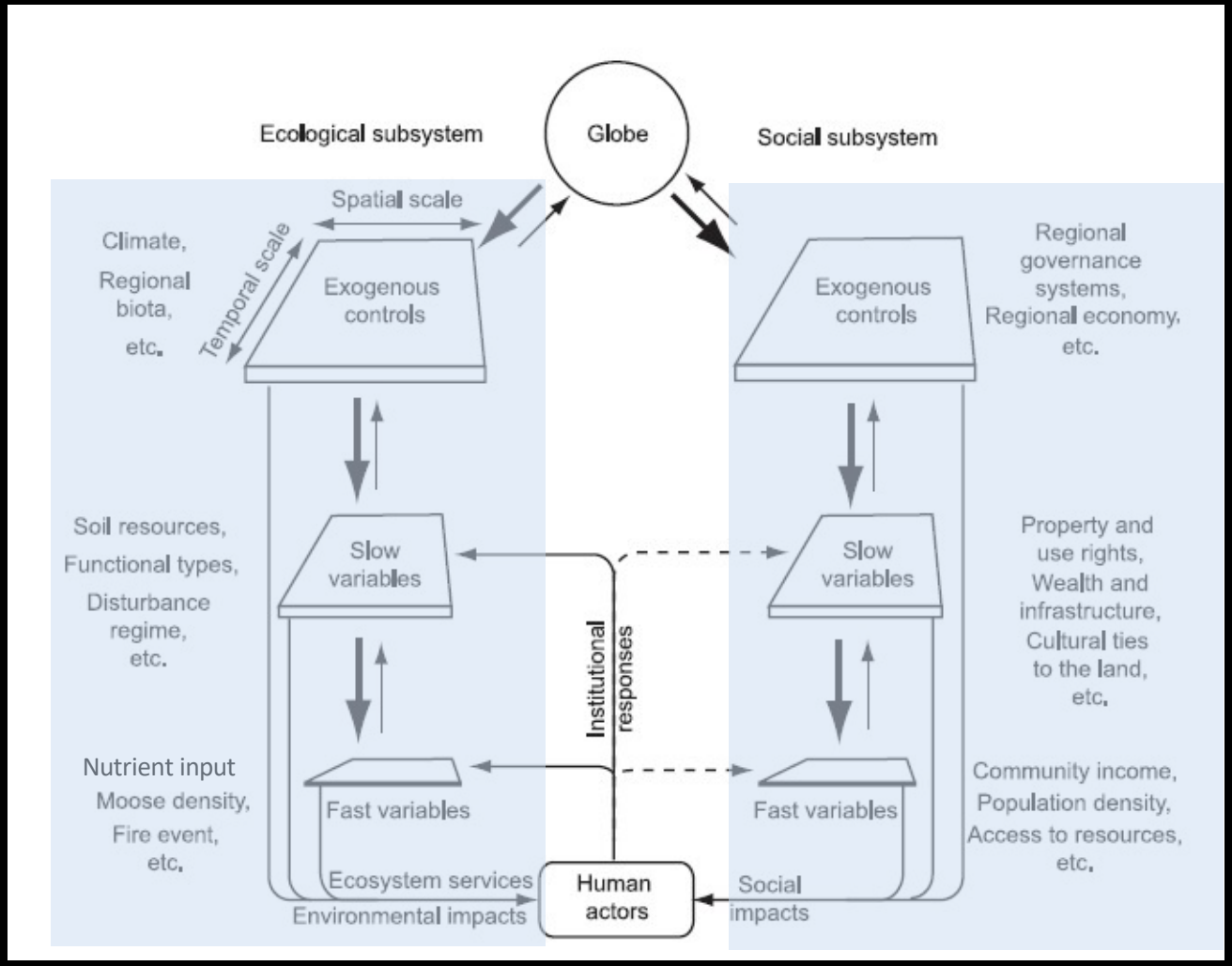
Slow vs. Fast Variables



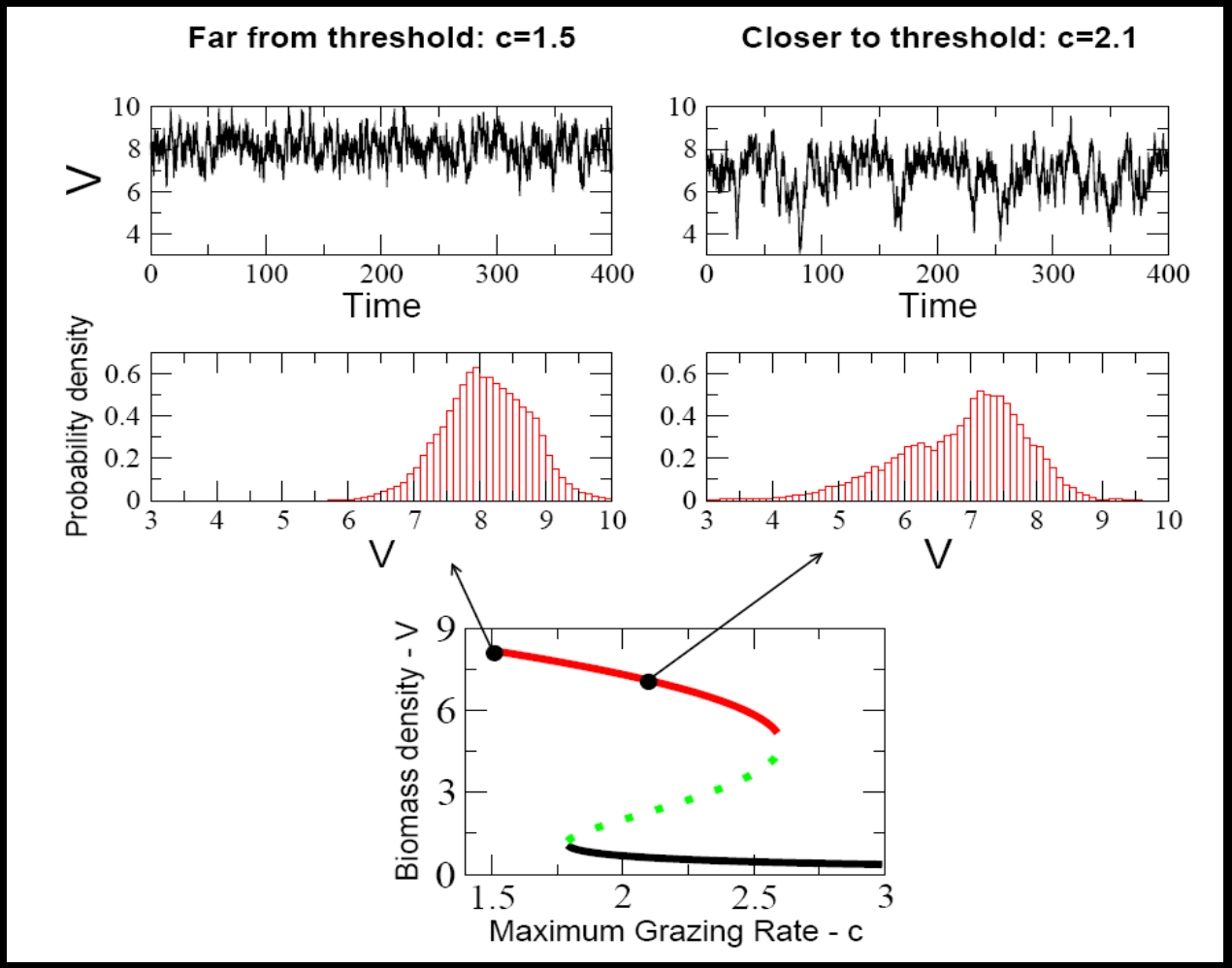
Examples of fast and slow variables

FUNCTION	EXAMPLES	SLOW	FAST
Primary Productivity	Carbon	C Stocks	CO2 Emissions
Nutrient Cycling	Nitrogen	N Retention	N Input
Hydrological Function	Water Quality	Temperature/ Sediments	Runoff
Biodiversity	Bird Diversity	Species competition	Habitat loss
Disturbance regimes	Flooding	Floodplain Connectivity	Control structures

Ecological vs. Social Variables



Skewness and Variance



Assignment 3: Indicators of Resilience

1. Define the resilience question relative to ecosystem function of your team
2. Identify key indicators of resilience
3. Select three key indicators that include at least one slow and one fast variable
4. Hypothesize future trajectories for the 3 selected indicators under each scenario
5. Define how your indicators will allow to deal with the challenges of early warning